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INDIVIDUAL PATTERN RECOGNITION OF *SPELEOMANTES ITALICUS* (DUNN, 1923)

(AMPHIBIA, PLETHODONTIDAE)

INTRODUCTION

Individual recognition of the animals by means of marking is one of the bases of most ecological studies. The marking of amphibians is especially difficult, problems arising from the often small size of the animals and their peculiar skin morphology and physiology; the several tecniques that have been so far proposed have both advantages and limits, which should be carefully taken into account according to investigation's aims (cf. Faber, 2001). Toe-clipping is still among the most commonly employed techniques, although it cannot be used in long-term researches on tailed amphibians, because of their high regeneration potential (about regeneration in *Speleomantes*, cf. Salvidio, 1997). Furthermore, the resulting injuries may increase the risk of mortality or affect animals fitness.

Pattern recognition is also among the most considerate methods for amphibians (especially Caudata), which effectiveness is comparable to that of other techniques, such as toe clipping and application of P.I.T. (Passive Integrated Transponders) (cf. Faber, 2001). This technique was first applied to *Speleomantes* by Salvidio *et alii* (1994), who used backlimb colour pattern to individually recognize *S. strinatii* (Aellen, 1958); herein we reports the results coming from pattern recognition of *S. italicus* (Dunn, 1923) over two consecutive years.

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MATERIALS AND METHODS

The study site is a tectonic cave called «Grotta del Tritone», located in northern Apennines (province of Forlì-Cesena, Italy).

The *S. italicus* population gravitating around the cave has been object of a long term study, in order to investigate several natural history traits of the species (cf. PASTORELLI *et alii* 2001, 2002a, 2002b and 2005).

The site was visited monthly from September 1998 to August 2000 (except for October 1998); all cave salamanders captured were measured and sexed by means of exterior sexual characters. Dorsal pattern was photographed under near-freezing water, in order to avoid reflections in images (cf. LANZA *et alii* 1995) and to speed up animal's immobilization; a transparent millimetered paper sheet laying on tank bottom provided an additional reference as regards to salamanders size.

Images were taken by a reflex camera 35 mm, equipped with a 100 ASA color slide film, and a flash-lamp. Date of capture, sex, body length (from snout tip to the anterior end of the vent), and identification code of each animal were recorded and stored up in a digital data bank. At the end of all sample sessions each salamander was released in the place where it was captured. Later, in the laboratory, for each specimen an identification mark was chosen: a single blotch, a group formed by few blotches, or an area lacking ochra-reddish pigments; then, individual recognition occurred by means of direct slide comparison.

RESULTS AND DISCUSSION

The studied population shows "*italicus*"-type colour and patterns, as described by LANZA *et alii* (1995): dorsal pattern with brown ground colour abundant and sometimes prevailing; ochra-reddish blotchings and/or marblings on the trunk and tail; pattern reduced or lacking on the head and neck, often more and more widespread towards the tail, where light markings usually overwhelm the darker ground colour (fig. 1); ventral pattern with dark ground colour (nut-brown to dark bistre) dusted or closely dotted with white or off-white.

Because of its wider range of colours and higher complexity, dorsal pattern was chosen instead of ventral one in order to recognize animals.

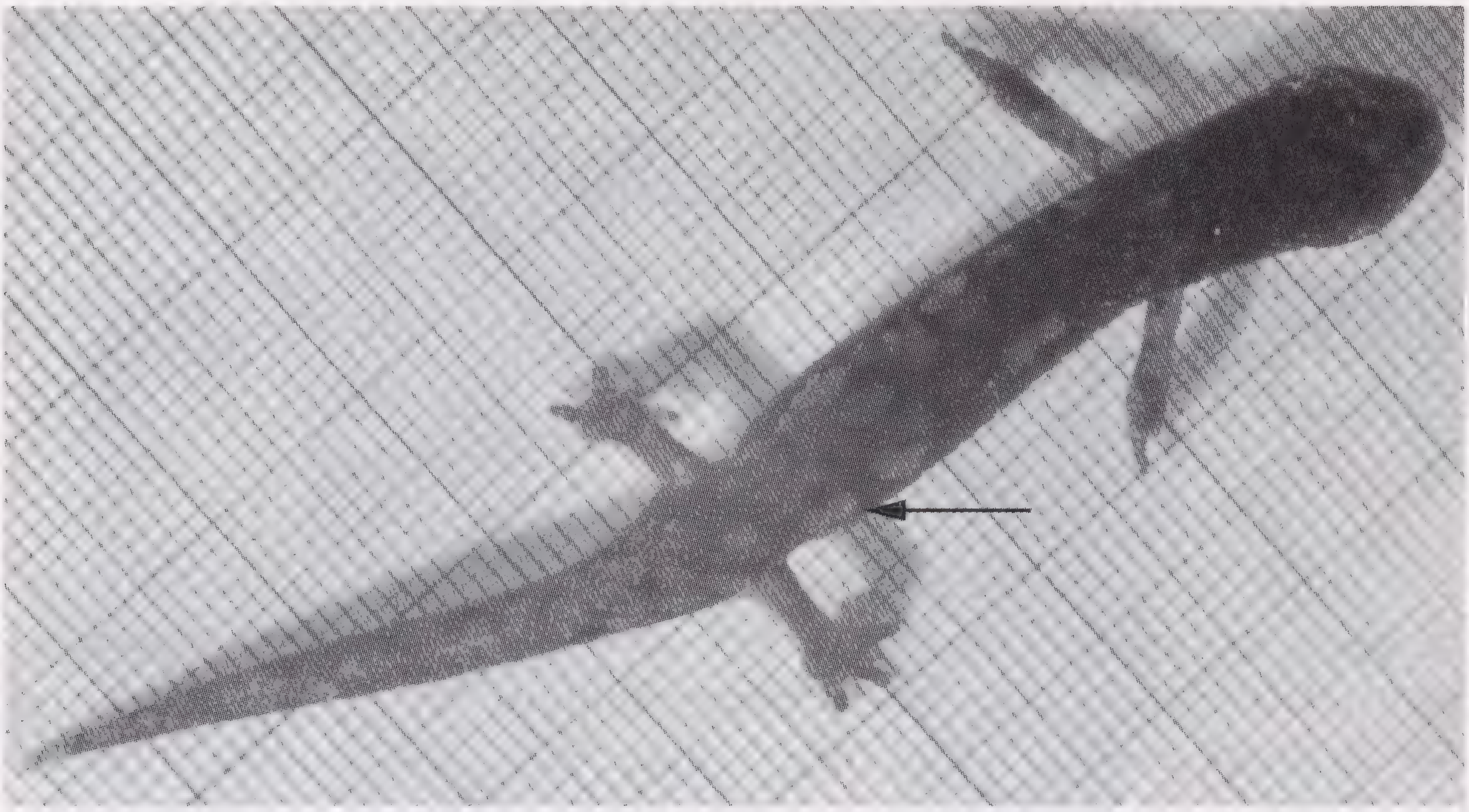

Fig. 1 - Example of *S. italicus* «mug shot». Male, «blotched» phenotype. The arrow indicates the «C» shaped blotch used as identification mark.

According to Lanza *et alii* (1995) dorsal pattern of *Speleomantes* is highly variable also within the same population. We arbitrarily recognized three main «pattern phenotypes» within the studied population [percentages of each phenotypes within a section of the sample (n = 96) have been cited in round brackets]:

1) «juvenile» (26.0%): dark ground colour prevailing, with only few, almost reddish or rarely ochra, dustings and speckles;
2) «blotched» (52.1%): ochra-reddish chromatophores arranged in quite defined blotches, variable in size and shape, pattern roughly corresponding to «*italicus*»-type described by Lanza *et alii* (1995);
3) «marbled» (21.9%): ochra-reddish chromatophores arranged in marblings, an intermediate pattern between «*reticulate*»-type and «*gormani*»-type of Lanza *et alii* (1995).

The frequency of phenotypes in the different sex categories is reported in tab. 1.

Tab. 1 - Percentages of each phenotype in the different sex categories, calculated for a section of the sample (n = 96).

Phenotype	Immatures	Males	Females
Juvenile	68.6	4.0	0.0
Blotched	25.7	76.0	61.1
Marbled	5.7	20.0	38.9
n	35	25	36

An identification mark should be easy recognizable, and durable. In order to match these conditions we chose blotches characterized by a relatively big size (less affected than speckles by pattern variations caused by age), a peculiar shape and a good contrast against the ground colour (allowing a quick spotting), and a middorsal position on animal's back (always noticeable in images, while blotches on sides may not be visible due to animal's torsion or inclination). Such blotches are more often found from the posterior half of salamander's trunk to the tail (86.5% of cases, in a sample section of 96 specimens), thus this is the body region on which attention should be focused for individual cave salamanders recognition.

Individual dorsal pattern also changes gradually with age. As already written, most of juvenile salamanders (15-28 mm in body length) display a pattern characterized by few reddish dustings and speckles on the darker ground colour. As the animal grows, due to the addition of ochra-reddish chromatophores, the small spots increase and sometimes merge into others to form larger blotches (fig. 2), the pattern turning gradually into «blotched» or «marbled» phenotypes.

Over the study period we were able to recognize 243 specimens: 118 adults (60 males and 58 females) and 125 immatures. 96 specimens were captured more than once (up to 8 times) and it was possible to recognize salamanders even two years after their first capture. As all the salamanders were collected within an area of 300 m^2, the extrapolated density is 0.8 individuals/m^2, that is exactly the same mean value estimated by SALVIDIO (1998) for *S. strinatii* sampled on a rock-face habitat. Quite lower density values were obtained for *S. supramontis* by VOESENEK *et alii* (1987: 300 animals/ha) and for *S. strinatii* by CORTESOGNO & BALLETTO (1989: 0.1 individuals/m^2), who sampled respectively in a dense holm oak forest and in a seepage area located in a beech forest.

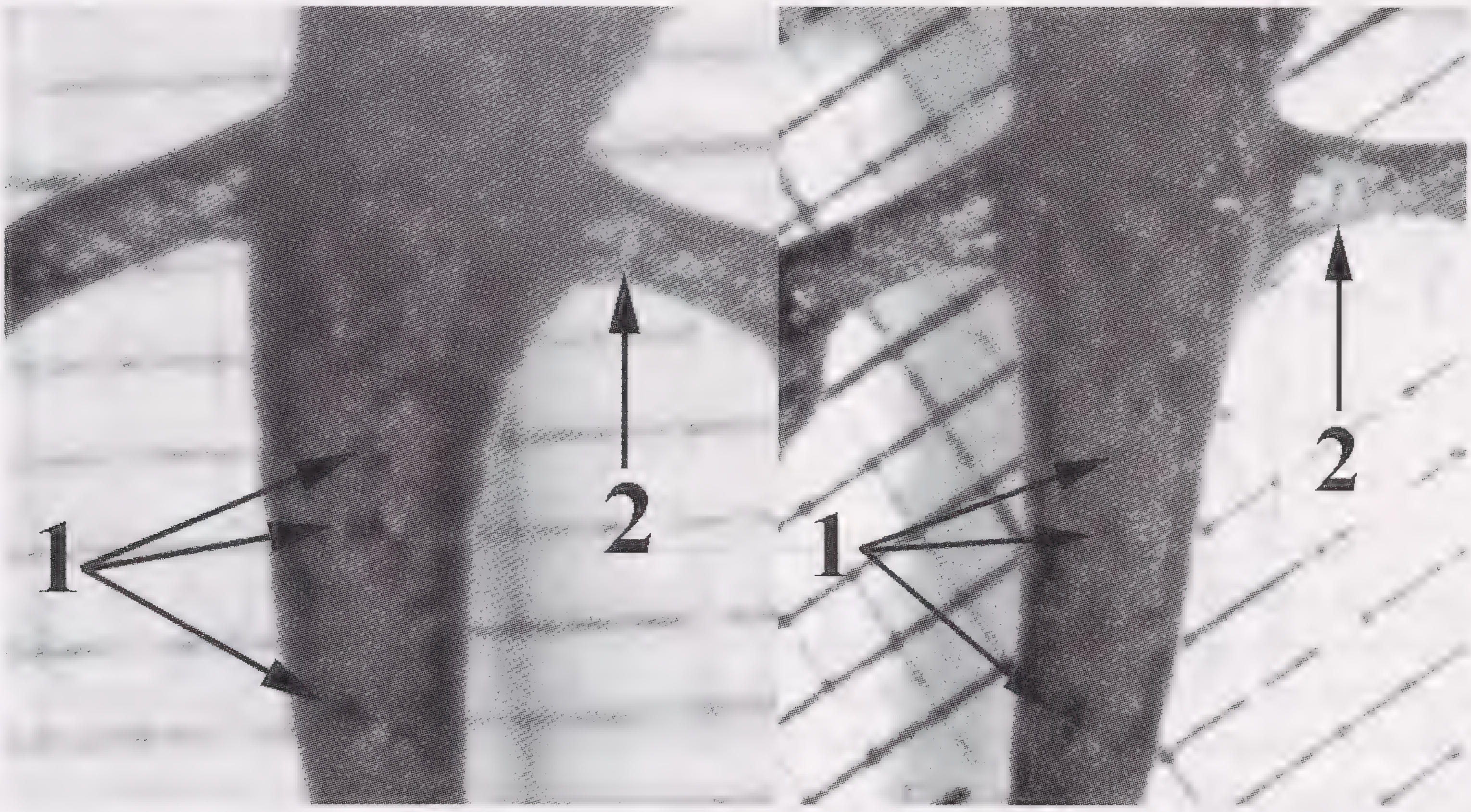

Fig. 2 - *S. italicus* pattern variations caused by age. Immature, «juvenile» phenotype. The arrows indicate areas with visible ground colour, that were progressively filled with reddish chromatophores (1), and the growth of a blotch, due to the appearance of new ochra chromatophores (2). Left = date of capture: May 17th 1999; body length = 16 mm. Right = date of capture: February 2nd 2000; body length = 24 mm.

Recapture rate (calculated for each sample session as % of known specimens on the total number of salamanders captured) averaged 48.8%, showing an increasing trend over the 24 months period (fig. 3).

In conclusion the technique proved effective in individual recognition of salamanders, moreover it allowed the collection of additional data about pattern variations within the sample. On the other hand some factors limit the applicability of the method (cf. FABER, 2001). Photographic techniques are quite laborious and expensive, and the risk of incorrect identification increase in direct proportion to the size of the sample. Also, pattern recognition should be carried out regularly, without interruptions; otherwise, the effectiveness of the method might be affected by pattern changes over the years (especially as regards to juvenile specimens), in proportion to the length of the discontinuance. Finally, the technique does not seem to be suitable for an automation by digital image analysis, due to the heterogeneity of mug shots.

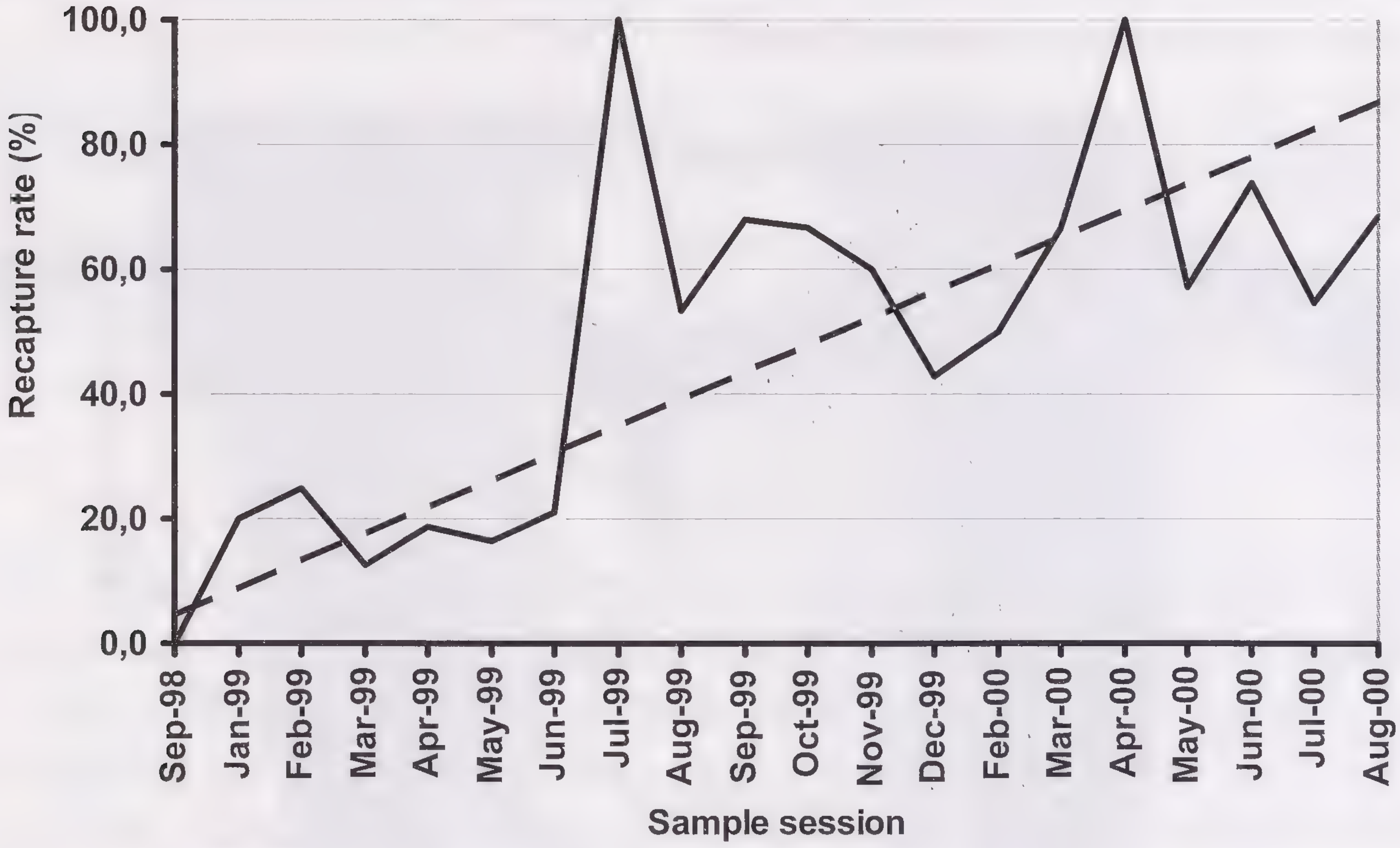

Fig. 3 - Recapture rate distribution over the study period; broken line shows the increasing trend.

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ABSTRACT

For two consecutive years individual recognition of *Speleomantes italicus*, by means of dorsal pattern «mug shots», was tested; pattern variations caused by age and among individuals were also recorded. Within the studied population three main «pattern phenotypes» were arbitrarily recognized. Juveniles display few, almost reddish speckles on the darker ground colour («juvenile» phenotype); as time goes by, speckles increase in larger markings, due to the appearence of ochra-reddish chromatophores. In larger immatures and adult salamanders light markings may be arranged in quite defined blotches («blotched» phenotype), as well as in marblings («marbled» phenotype).

Over the study period 243 cave salamanders (60 males, 58 females and 125 immatures) were individually recognized, and salamanders recognition was possible even two years after their first capture. In agreement with those observed for *S. strinatii*, the calculated density of *S. italicus* was 0.8 individuals/m^2. Recapture rate showed an increasing trend over the 24 months period, averaging 48.8%.

The technique proved effective in individual recognition of salamanders, although quite laborious and expensive, as well as not suitable for an automation by digital image analysis.

RIASSUNTO

Riconoscimento tramite il disegno individuale di *Speleomantes italicus* (Dunn, 1923) (Amphibia, Plethodontidae).

Per due anni consecutivi è stato sperimentato il riconoscimento individuale di *Speleomantes italicus*, mediante fotografie della colorazione dorsale; sono state inoltre registrate le variazioni della colorazione tra i diversi individui, nonché in funzione dell'età. All'interno della popolazione studiata sono stati arbitrariamente riconosciuti tre principali fenotipi di colorazione. Gli individui giovani hanno poche macchioline, per lo più rossastre, sul colore di fondo più scuro (fenotipo «giovanile»); col passare del tempo le macchioline si estendono in macchie più grandi, grazie alla comparsa di cromatofori ocra-rossastri. Negli individui immaturi più grandi e negli adulti le ornamentazioni chiare possono essere organizzate sia in macchie piuttosto definite (fenotipo «macchiato»), che in marmorizzazioni (fenotipo «marmorizzato»).

Nell'arco del periodo di studio sono stati riconosciuti individualmente 243 geotritoni (60 maschi, 58 femmine e 125 immaturi) e il riconoscimento è stato possibile fino a 2 anni di distanza dalla prima cattura. In accordo con quanto osservato per *S. strinatii*, è stata calcolata per *S. italicus* una densità di 0,8 individui/m^2. Nell'arco del periodo di 24 mesi il tasso di ricattura ha mostrato una tendenza all'incremento (media = 48,8%).

La tecnica si è dimostrata efficace per il riconoscimento individuale dei geotritoni, seppur piuttosto laboriosa e dispendiosa, nonché inadatta ad un'automazione tramite analisi d'immagine digitale.